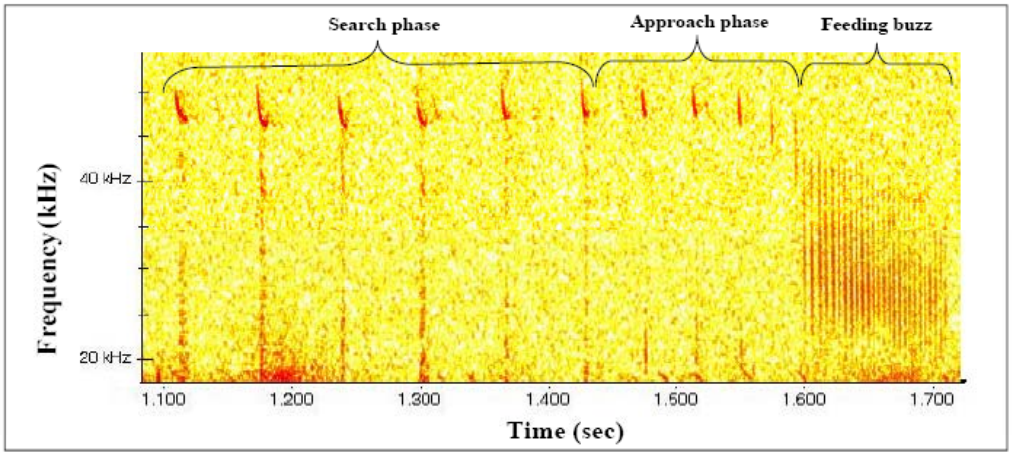
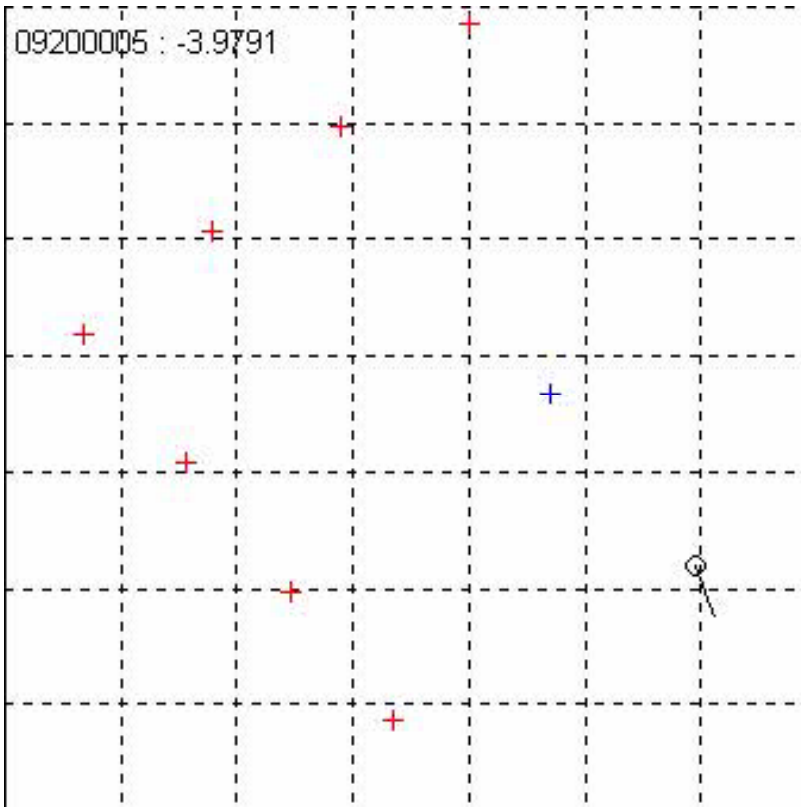
Anti-predator behavior

Predation vs. anti-predation

Evolutionary arm race

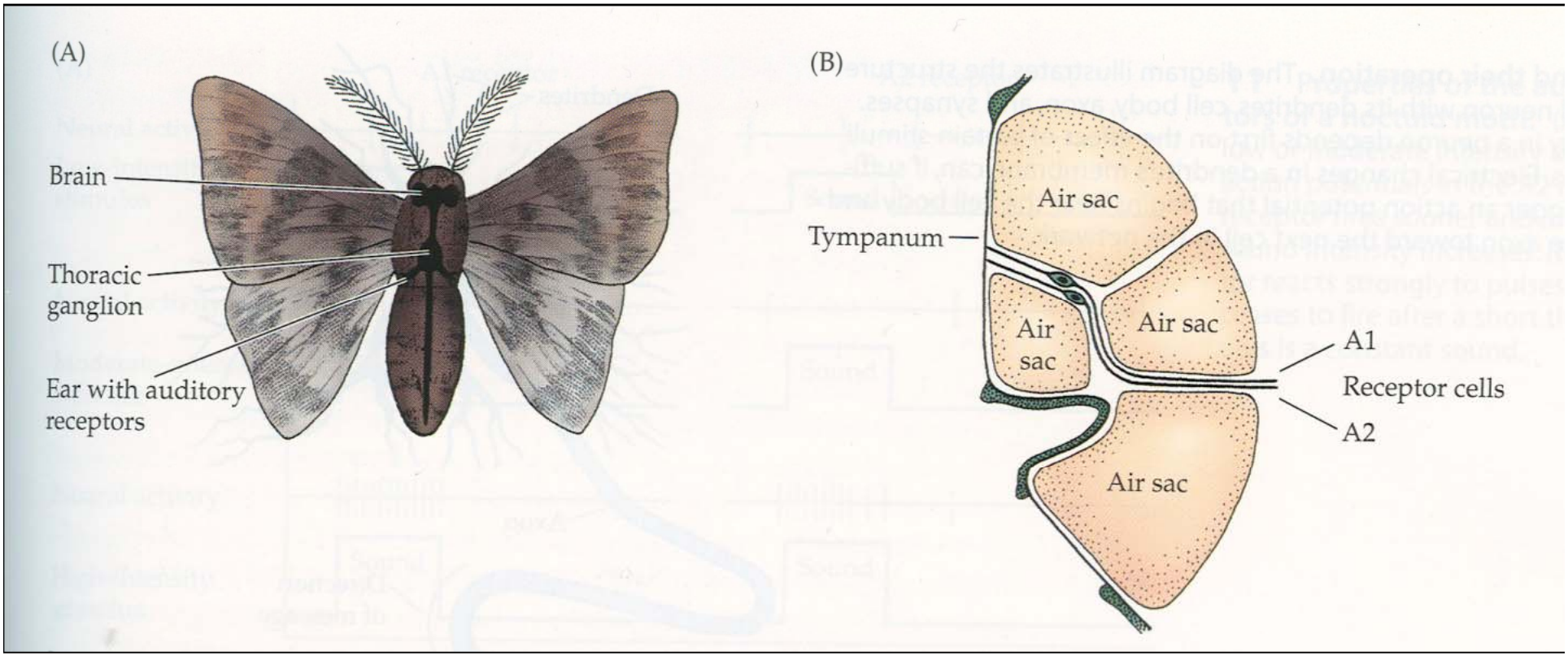
Anti-predation by moths

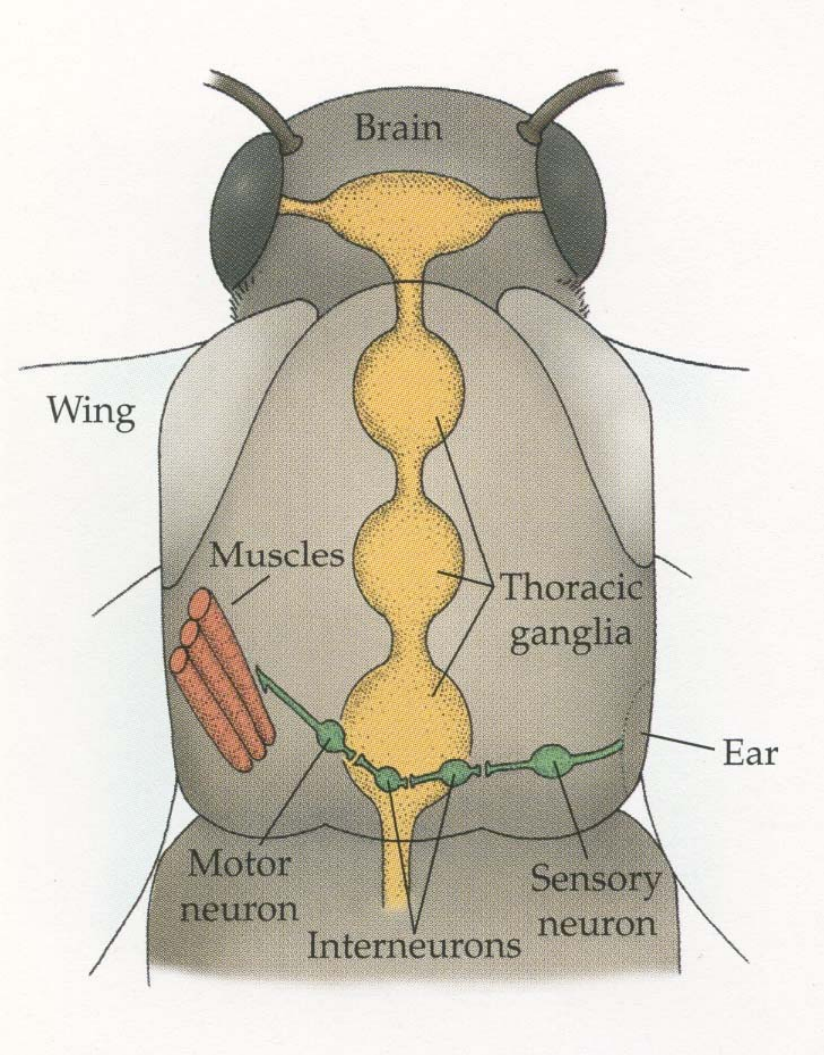




Bat vs. moth

How do moths detect ultrasounds and escape ?





Ultrasound wave

Mechanically change
the tympanum membrane

Vibration induces nerve pulse
--“action potential”

Transmit from sensory neurons
To interneurons through synapse

Interneurons to motor neurons

Muscle movement, escape

The prey (moth) evolves anti-predation strategy

Anti-predation strategy:

Two categories

1. Avoiding detection by predators

2. Encountering predators

1. Avoiding detection by predators

Cryptic: (hidden through camouflaging)
blending into environment

Examples?

Examples of camouflage

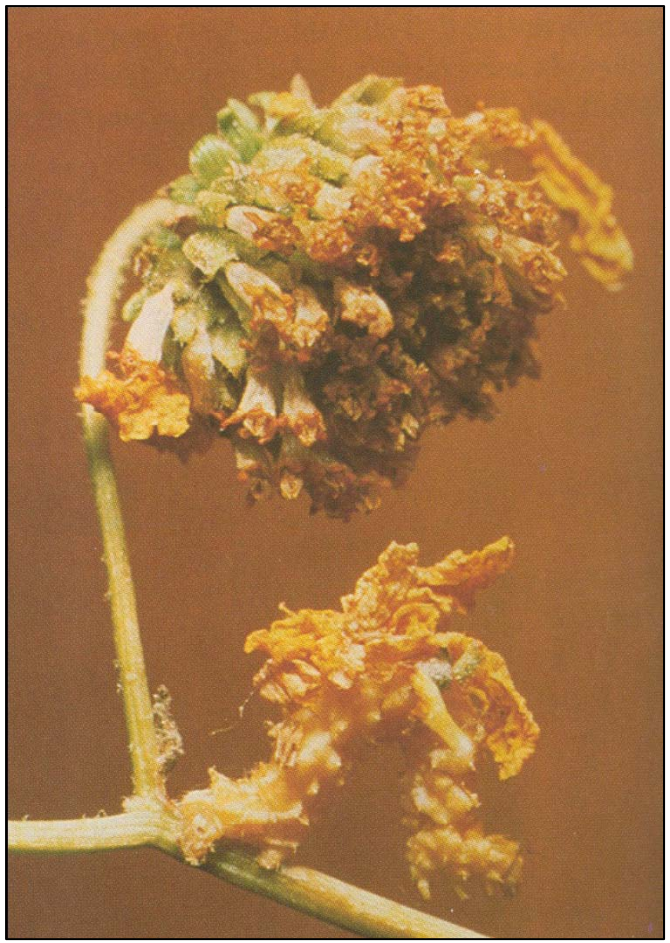
Rock ptarmigan

The same individual that can change plumage seasonally and match the local environment

Winter plumage

Summer plumage

Examples of camouflage



Improve camouflage……

Geometrid moth caterpillar hooks flower petals onto its back

Examples of camouflage: grasshopper

Evolution of camouflage through natural selection

Peppered moth

Black form once extremely rare
Light form dominant
in urban regions of England

From 1850-1950:
Black form replaces light form

Hypothesis: industrial soot had darken the color of forest trees
→ Predators (birds) eat lighter ones

Moth vs. polluted tree

Before 1800

Lighter background (trees)

1850-1950

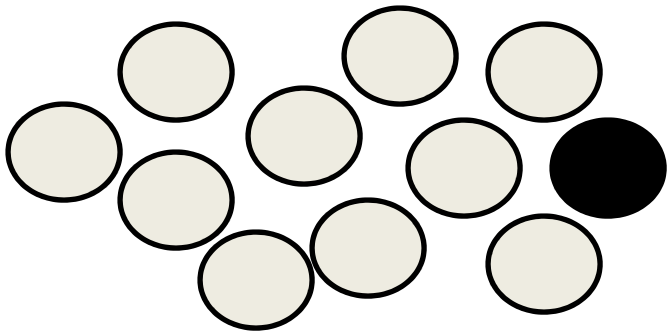
Darker background (trees)

A good example of natural selection

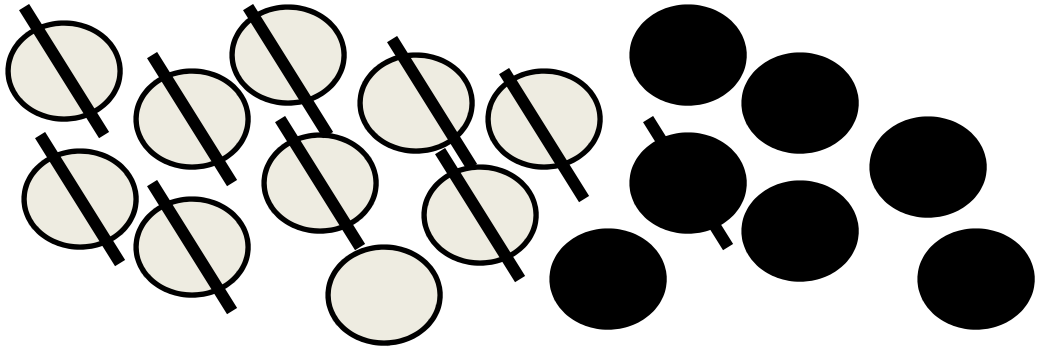
Black form
a gene is mutated to black

Whitish form

Before forest darkened

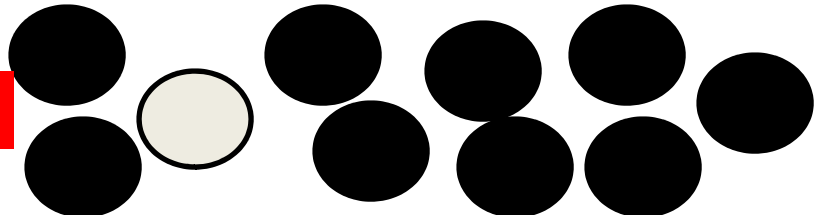


After forest darkened



After forest darkened

Mutated gene survives



Does cryptic behavior work?

How to design an experiment test whether bird predators are harder to detect cryptic prey?

Predator can learn the “search image” of cryptic an non-cryptic preys

What kind of associative behavior it is?

Anti-predation strategy:

Two categories

1. Avoiding detection by predators

2. Encountering predators

Anti-predation strategy:

Two categories

1. Avoiding detection by predators
   -cryptic behavior
2. Encountering predators
   - warning signals

Encounter predators:

1. Warning predators

Warning predators
(don’t eat me, I am poisonous)

Anti-predator strategy:

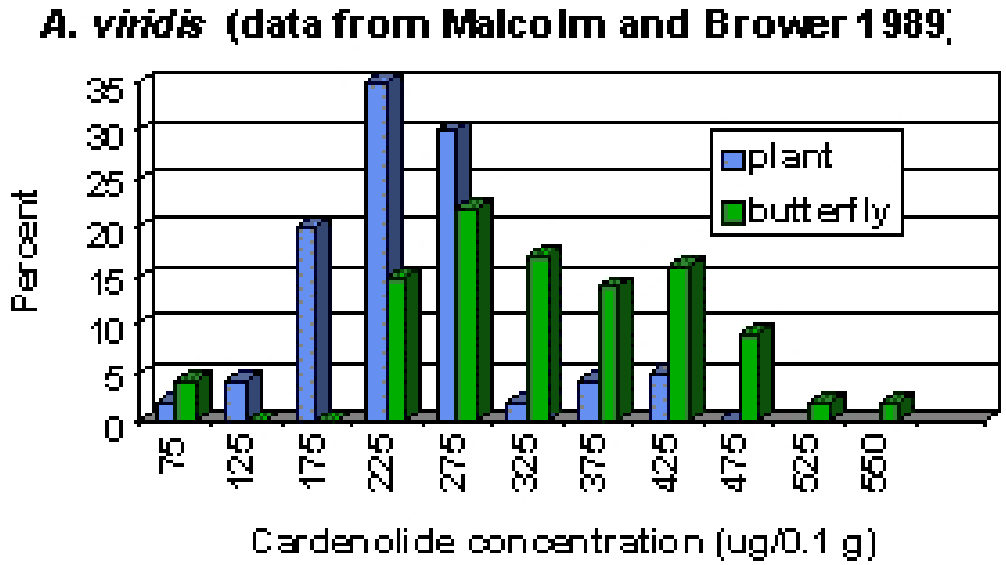
Conspicuous orange and black pattern on its wings.

The larvae feed upon poisonous milkweeds, they save the potent plant poison in their tissues

Anti-predator strategy:

Figure 1

Milkweed and Monarch Cardenolide Concentrations



Its larvae feed upon poisonous milkweeds, they save the potent plant poison in their tissues

Encounter predators:

What anti-predator strategy the monarch butterfly has evolved against its predators?

Warning against predator

Blue jays eats the butterfly and survives,
but the toxic is the most unpleasant, educational experience
This jay would never eat any bug with black-yellow pattern.

Aversive conditioning

Nauseated predators learn to avoid the color pattern of the prey that make them sick, the door for deception is opened!

Some edible, non-poisonous prey deceive educated predators into leaving them alone by looking like bad-tasting ones…

Batesian mimicry

The protective resemblance in appearance of a palatable or harmless species to an unpalatable or dangerous species that is usually avoided by predators.

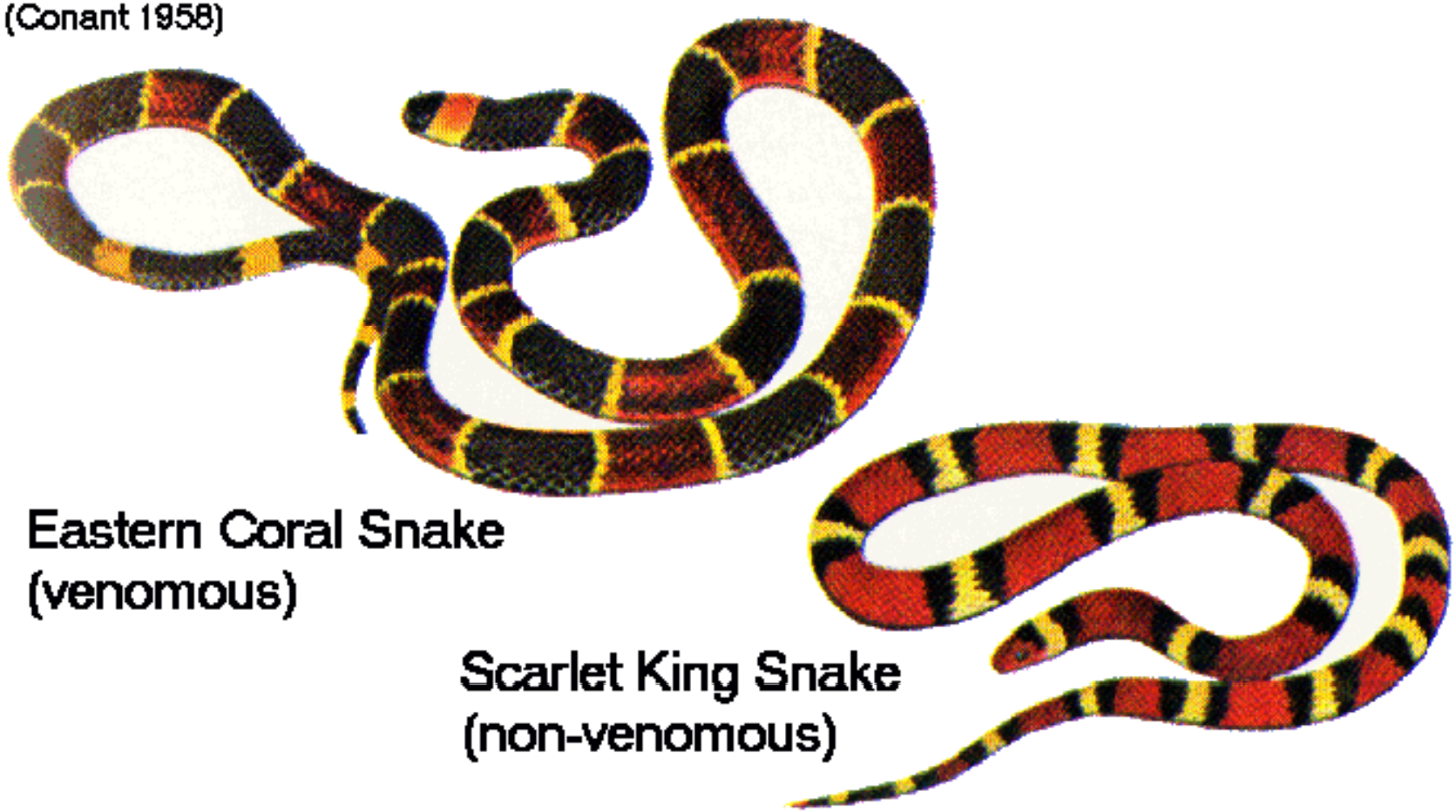
Batesian mimicry

FIGURE 18.20. Batesian mimicry in females of the swallowtail butterfly *Papilio dardanus*. The *left* column shows three different unpalatable model species in the family Danaidae, and the *right* column shows palatable *Papilio dardanus* mimics. All three patterns are found as polymorphisms within populations of *P. dardanus*.

The Batesian mimicry occurs when two species live at the same area.

Batesian mimicry

(Conant 1958)



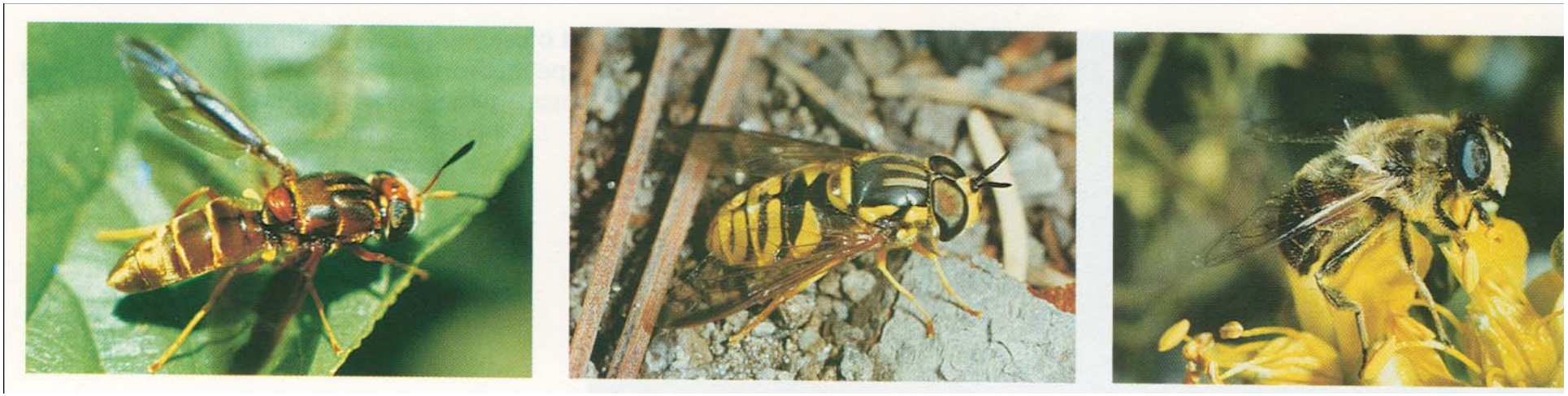
Eastern Coral Snake
(venomous)

Scarlet King Snake
(non-venomous)

Batesian mimicry

They look like..

a paper wasp a yellow-jacket a bee



But actually they are harmless flies

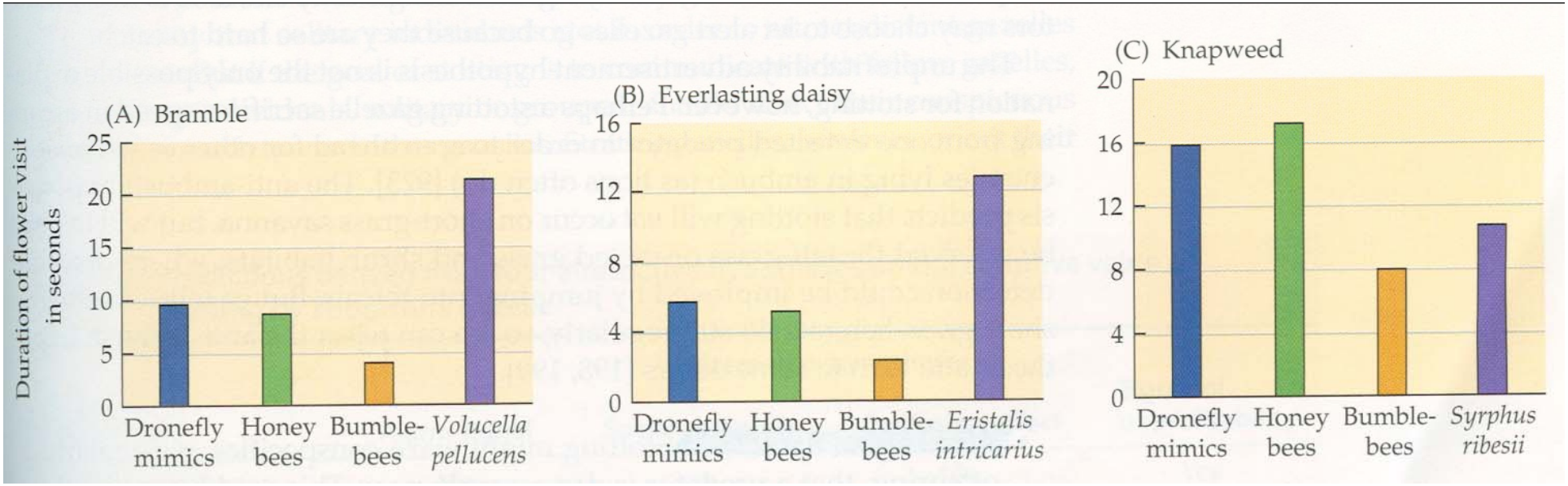
Batesian mimicry

(a) Cuckoo bee

(b) Yellow jacket

Behavioral Batesian mimicry

Droneflies that mimic honey bees spend about the same amount of time as honey bees feeding on the flowers of various plants



Mullerian mimicry

Müllerian mimicry is a natural phenomenon when two or more harmful species, that may or may not be closely related and share one or more common predators, have come to mimic each other's warning signals.

Mullerian mimicry

Tree frog: D. fasiri

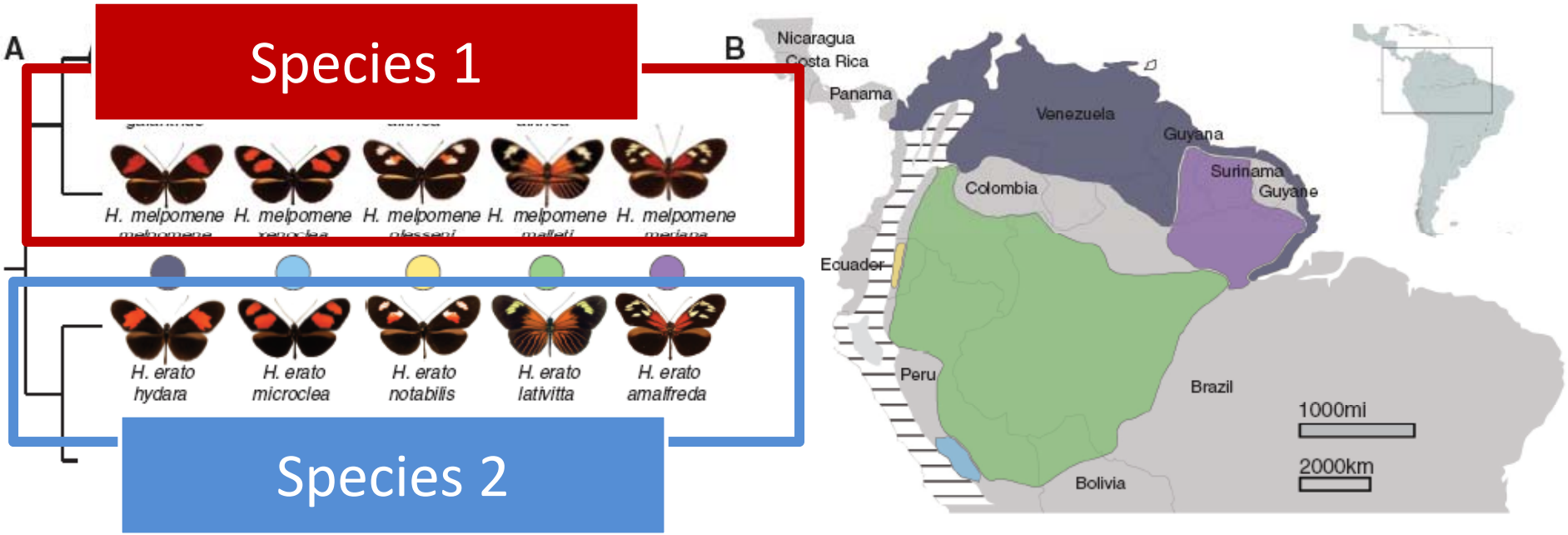
D. summari

Mullerian mimicry (both frogs are poisonous)

Tree frog: D. fasiri

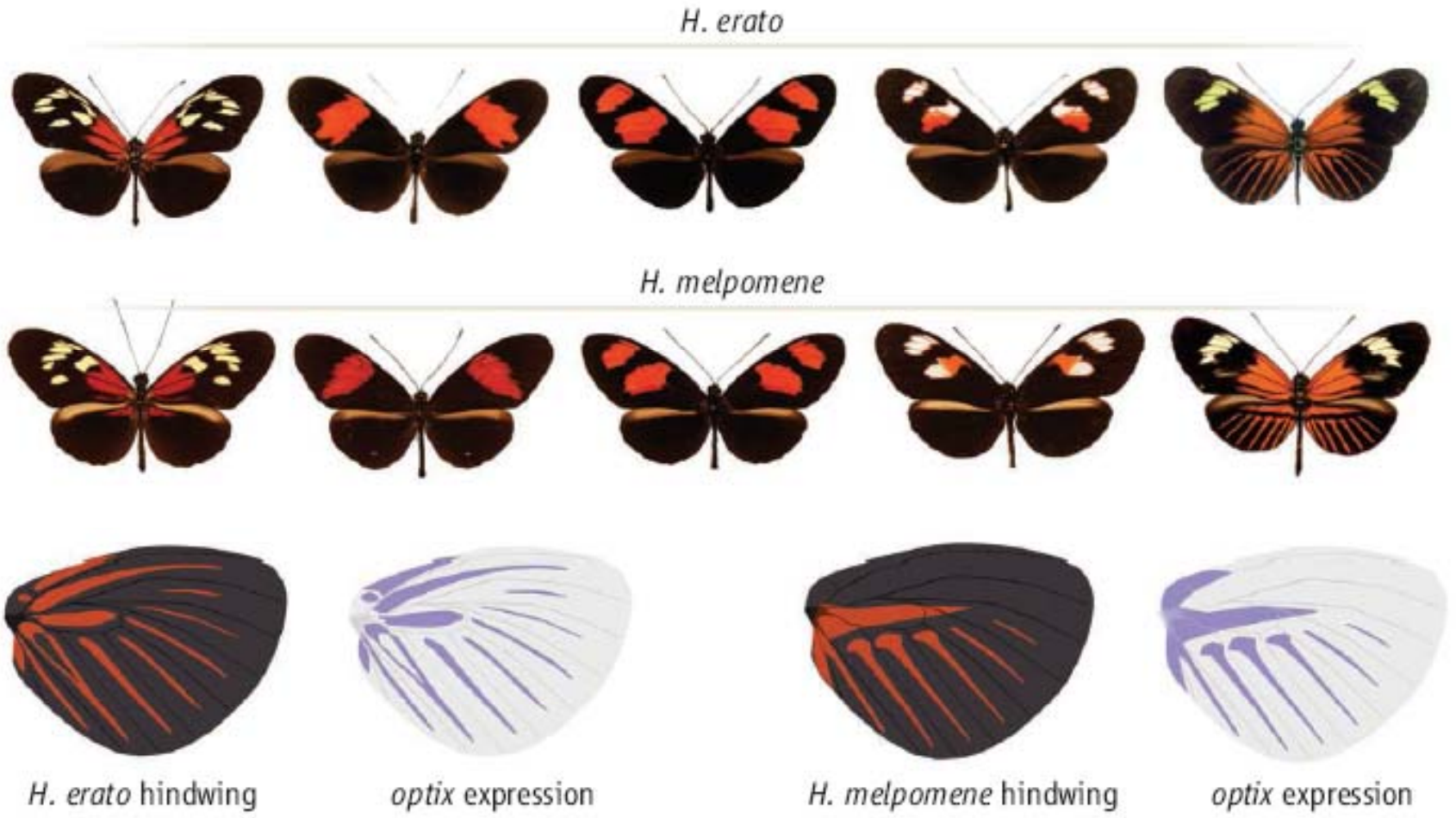
D. summari

Mullerian mimicry



Two different species at the same area evolve mimicry of color pattern

The differential expression of a single gene (*optix*) induces the color change



The differential expression of a single gene (*optix*) induces the color change:

These two species have the exact same *optix* gene – same coding sequence (same amino acid sequence)

The only difference is the non-coding region: one species induce gene expression in some tissues but not the other species.

The only difference is the non-coding region: induce gene expression in some tissues but not the other species.

Optix gene coded for red color

Encounter predators:

1. Warning behavior

2. Stay vigilant to flee

Stay vigilant to flee

A sleeping duck is only half asleep

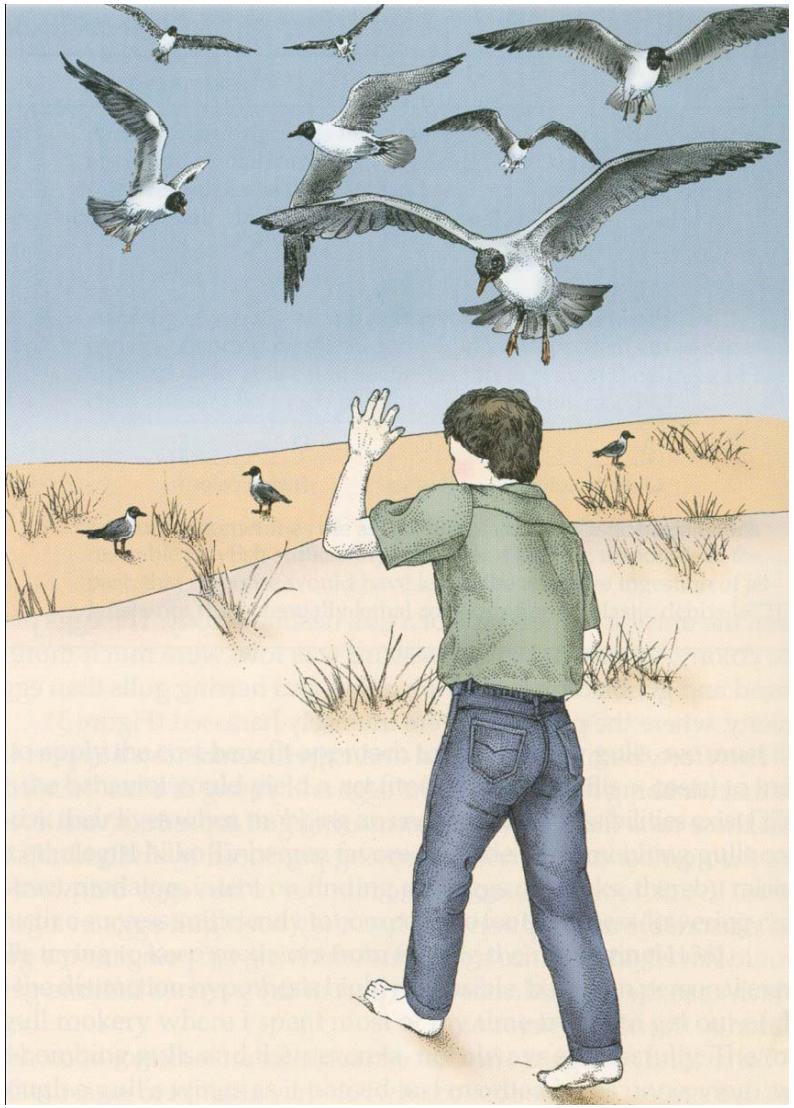
One of the hemispheres of these ducks was functioning at 100% capacity while the other hemisphere was in a sleep mode. Apparently the duck has the capacity to sleep with half the brain at a time doing the sleeping and the other half being fully responsive to the environment around them.

Stay vigilant to flee ducks sleep in a group

Encounter predators:

1. Warning behavior
2. Stay vigilant to flee
3. Attacking predator

Mobbing behavior



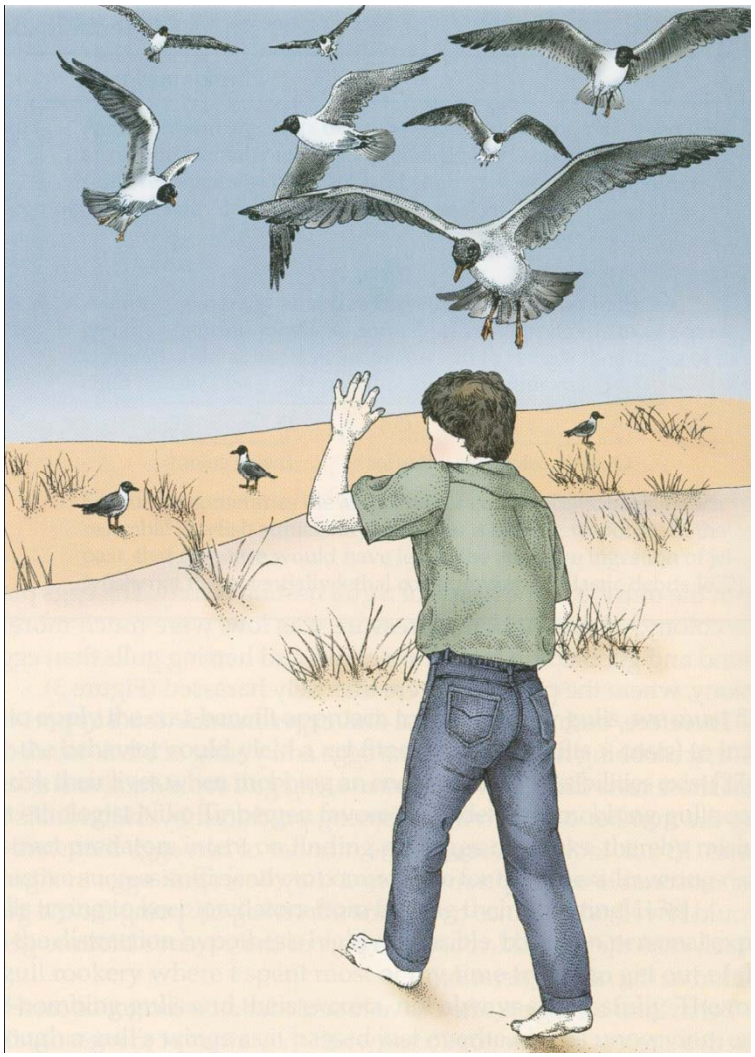
Usually evolved in colonial ground-nesting birds, or mammals.

-- black-headed gull

What if there is no (or less) selective pressure of predation?

Will anti-predation behavior still be evolved?

Mobbing behavior of black-headed seagulls



Hypothesis: in Black-headed Seagulls, mobbing behavior is an anti-predation strategy.

Prediction: If they have no or less predator, they would not evolve mobbing behavior.

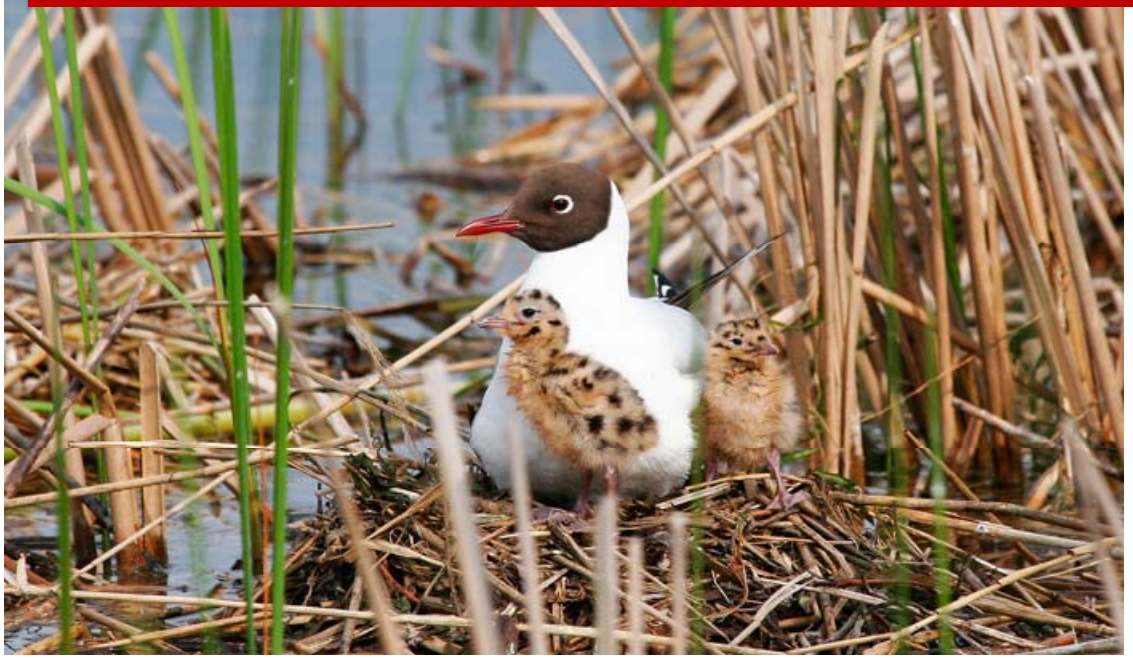
Black-headed gulls
ground-nesting species, eggs and chicks
are more vulnerable to land predators

No predator →
No mobbing behavior

Close-relatives of black-headed gulls: Kittiwake gulls are cliff-nesting species, have much less predator pressure

Kittiwake gull's chicks

No predation pressure, no camouflage evolved



Black-headed gull's chicks

What if there is no (or less) selective pressure of predation? Island species

Will anti-predation behavior still be evolved?

Many Island species have less or no natural predators

These species gradually lost anti-predation behavior

They have no fear toward humans (and predators…)

Island species have less or no natural predators

Gradually lost anti-predation behavior

Many species are flightless and slow…

A cormorant species in New York

Flightless cormorant in Galapago's island

Island species have less or no natural predators

Gradually lost anti-predation behavior

They are flightless and slow…

Flying steamer ducks in Argentina

Flightless steamer ducks in Falkland's island

Island species have less or no natural predators

Gradually lost anti-predation behavior

Many of them are flightless and slow…

Flying parrots

Flightless parrots (kakapos) in a New Zealand island

Island species have less or no natural predators: many of them lost their defense mechanisms against predators.
If alien species were introduced….

In the last 500 years, introduced alien species have contributed to the extinction of nearly half of global bird extinctions, mostly by humans and introduced rats, cats, diseases.

In islands, many ground nesting birds have not evolved defense strategies against introduced cats, dogs, rats…..

→ species went extinct,

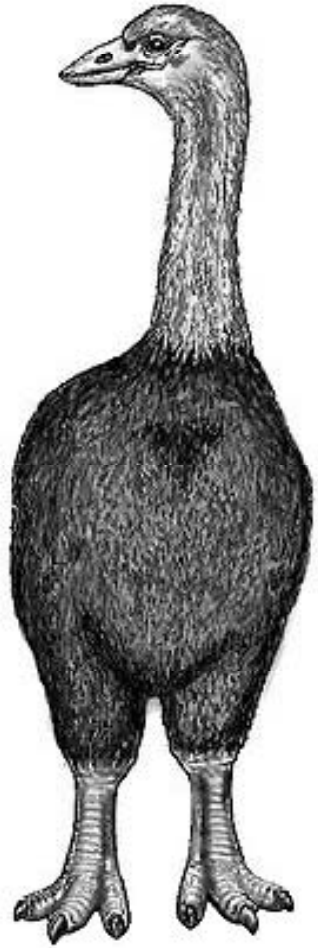
Islands: ground nesting birds

Island flightless birds went extinct due to human activities

Dodo birds

Stephen island wrens

Hawaii rails



Elephant birds

Introduced species may change the local habitat and impair local species diversity.

-- extinction

Invasive Plant Threatens Midway Atoll Seabirds

Over 2,000,000 birds are densely packed into Midway Atoll's 1600 acres. The atoll is home to the endangered short-tailed albatross, the endangered Laysan duck, and the largest populations of Laysan albatross, black noddy, white tern, and red-tailed tropicbird in the world.

Among the 225 non-native plants on Midway Atoll, golden crownbeard is the most invasive, its spread reducing nesting habitat for all ground-nesting birds.

Golden Crownbeard

- scientific name: *Verbesina encelioides*
  Family: Asteraceae
- an annual flowering shrub
- native range is debated, but believed to be tropical America and North America
- in its native habitat, grows from 1 to 5 ft in height at elevations from 0 to 9000 ft
- is drought-tolerant, requiring only monthly waterings once established
- its flowers produce up to 350 seeds by both cross- and self-pollination
- seeds exhibit their highest rate of germination in open, disturbed areas with sandy soils
- seeds fall from the plant where they reseed existing stands and are also dispersed by wind

Golden crownbeard affects the success of nesting seabirds in several ways:

- Birds do not build nests in existing stands of golden crownbeard; so, existing stands decrease habitat available to nesting birds.
- The growth of new stands of golden crownbeard in areas where birds have already nested enclose and entrap chicks, preventing their parents from locating them for feeding and/or preventing them from finding their way to the ocean when it is time to fledge. These chicks die of starvation.
- Golden crownbeard serves as a home to aphids and scale insects and the ants that tend them. These ants may prey on the eggs and chicks of ground-nesting seabirds and waterfowl. (The scale insects and/or the ants are also suspected in the transmission of a harmful virus from golden crownbeard to native vegetation.)

With the exception of five species, all of Midway Atoll's seabirds nest on or in the ground.

Nine species nest directly on the ground, usually within a shallow, loose bowl of twigs or rocks:

Laysan albatross →
black-footed albatross
short-tailed albatross
red-tailed tropicbird
white-tailed tropicbird
Christmas shearwater
masked booby
gray-backed tern
sooty tern

Two species nest in burrows in the sand:

wedge-tailed shearwater
Bonin petrel

Photo Credit: Christy Finlayson

Introduced plants change the breeding habitat of many seabirds

Introduced Golden Crownbeard

Everybody can make a difference